Introduction to 3D

7

Contents

Contents

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Note:

This condensed version of CADD PRIMER is intended to give you an overview of CADD. It includes only important topics from CADD PRIMER. It does not include any diagrams. CADD PRIMER includes more than 100 diagrams that illustrate the working of CADD. For complete understanding of CADD refer to CADD PRIMER. This complete book is available for download for $9.95 at http://www.caddprimer.com or you can order printed copies through the publisher listed at the end of this chapter.

About this Chapter

This chapter introduces you to the general principles of 3D (three-dimensional) drawing that are commonly used in CADD. It describes how to make use of simple 2D functions to create a 3D effect, as well as how to create actual 3D models. You will learn how to measure distances in 3D, how to enter 3D coordinates and how to draw 3D shapes.

This chapter describes a number of 3D drawing techniques that are commonly used by CADD professionals. You will learn how to extrude 3D objects from simple 2D shapes, how to take advantage of 3D ready-made objects and how to make the views look realistic.

You will also learn how to display 3D views of a model from different angles.

Although the actual working of 3D CADD varies from program to program, the principles described here can be applied to most programs.

Key Terms in this Chapter

Term	Description
Isometric	A view of an object tilted at 30° on both sides.
Oblique view	A view of an object drawn by taking parallel projections from an elevation.
Perspective	A view of an object showing true angles as they would appear from a specific point.
3D modeling	A CADD capability that allows you to draw objects as physical objects having length, width and height.
3D coordinates	The mode of measurement used to specify the length, width and height of objects created by 3D modeling.
Viewpoint	The point from where a 3D model is viewed.
Linear extrusion	A 3D technique that allows you to form 2D shapes into 3D shapes along a linear path.
Radial extrusion	A 3D technique that allows you to form 2D shapes into 3D shapes along a circular path.

Why 3D?

3D capabilities allow you to draw pictorial views such as isometrics, oblique views and perspectives. The views drawn with CADD have a number of advantages as compared to views drawn on a drawing board. The views drawn with CADD are very accurate and provide a lot of flexibility in terms of editing and display. You can rotate a model on the screen just like an actual model, and display views from different angles.

Designers often use 3D to visualize designs and to make presentations. It helps them understand how an object will appear from different angles. Using additional rendering programs can further enhance the drawings.

Although working with 3D CADD programs is quite complex, it is worth the extra effort to make use of them. Many users never take the time to learn the 3D capabilities of CADD. This can be a major disadvantage because the full potential of CADD is never explored.

Pictorial Views Concept

How do we create 3D views on paper or on a computer screen, which are only two-dimensional media? Is an isometric or perspective 2D or 3D?

The views that we draw on two-dimensional media are a 2D representation of 3D images. We create isometrics and perspectives on paper by drawing objects as they would appear from a specific angle and distance. The same concept is used in CADD to draw pictorial views.

There are two distinct ways to draw 3D views with CADD: You can draw views using simple 2D functions or using CADD's special 3D functions.

The 2D functions allow you to draw views just like on a drawing board. You can draw a view using lines, arcs, or other 2D objects. This is the quickest method to draw simple isometric and oblique views. However, a view created this way is static; just like a view created on a drawing board. If you need to view the object from a different angle, you will have to draw it again from scratch.

CADD provides special 3D functions that allow you to create 3D drawings that are true representations of an actual model. These drawings can be viewed from any angle just like a physical model. That is why 3D CADD drawings are called 3D models.

The major distinction between a 2D drawing and a 3D model is that a 2D drawing is defined only with two coordinates (X and Y). A 3D model is defined with three coordinates (X, Y and Z). The Z-coordinate determines the height of an object. To make a 3D model, you need to consider all the objects of the model in 3D space and enter the X, Y and Z coordinates for all drawing objects.

3D modeling is described later in this chapter. Let's begin with simple oblique and isometric examples.

Oblique Views

Oblique views are the simplest form of the pictorial views that can drawn by using parallel projection lines from an elevation. There are standards established to draw oblique views at specific angles. A common standard used is to draw an oblique view by projecting lines at 45°. To measure depth along a 45° angle, you need to scale it down by 3/4 or 1/2 of the actual distance. For example, if the actual depth of the object is 1'-0", you measure 9" or 6". The 3/4 scale factor creates an effect as if the object is viewed from a slightly higher angle than the 1/2 scale factor. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Isometric Views

Isometric views are more realistic than oblique views. The object appears to be tilted at a 30° angle on both sides . An isometric is defined by three planes called isoplanes: top isoplane, right isoplane and left isoplane.

On a drawing board, we use a 30° triangle to draw the three planes of an isometric. The same principle is applied in CADD with the help of various functions. The right isoplane is drawn with 30° and 90° angles, the left isoplane with 150° and 90° angles and the top plane with 30° and 150° angles. All distances are measured using 1:1 scale (actual size) to show depth, width and height. You can use simple 2D functions and draw lines at specific angles to complete an isometric. Polar coordinates are particularly helpful to measure distances along an angle.

Steps to Draw an Isometric

(This topic is described in detail with the help of illustrations in CADD PRIMER).

Isometric Drawing-Aid Functions

The following are some of the important CADD functions that simplify isometric drawing. These topics are described with the help of illustrations in CADD PRIMER.

Isometric Grid

Fixed Cursor Direction

Isometric Circles, Text and Dimensions

2D Drawings to Isometrics Conversion

3D Modeling

CADD's 3D modeling capabilities allow you to create 3D images that are as realistic as the actual objects. These images are called 3D models because, just like a physical model, they can be rotated on the screen. You can display views from a 3D model, such as isometrics or perspectives, from any angle with a few simple steps.

3D modeling is usually a separate CADD module that has its own set of functions. Some manufacturers market 2D programs and 3D programs as separate packages while others combine them into a single program.

The 3D models fall into the following categories:

- Wire-frame models
- Surface models
- Solid models

Note: The above topics are described in detail with the help of illustrations in CADD PRIMER.

Working with 3D Coordinates

3D coordinates are measured with the help of three axes: X, Y, and Z. The axes meet at a point in the shape of a tripod. This point is called the origin point, which is the 0,0,0 location of all coordinates. All distances can be measured using this point as a reference. (Illustrated with Fig. In CADD PRIMER)

The three axes form three imaginary planes: XY plane, XZ plane and YZ plane. The XY plane is the horizontal plane and the XZ and YZ are the two vertical planes. When you need to draw something horizontal, such as the plan of a building, you draw it in the XY plane using X and Y coordinates. This generates a plan view. When you need to draw something vertical, such as an elevation of a building, you draw it using the XZ or YZ planes.

Example: To draw a line in 3D, enter two end points defined with X, Y and Z coordinates. If you need to draw the line lying flat on the ground (XY plane), the Z coordinate for both the end points of the line is zero. If you want to draw the same line at 10'-0" above the XY plane, enter the Z-coordinate for both the end points as 10'-0".

The 3D coordinates can be entered using the following formats:

- Cartesian coordinates
- Spherical coordinates
- Cylindrical coordinates

Cartesian Coordinates

Cartesian coordinates are based on a rectangular system of measurement. In Chapter 2 "CADD Basics", we discussed how Cartesian coordinates are used in 2D drawings. The same principle is applied to enter 3D coordinates with the exception that you need to enter an additional Z coordinate. Positive Z-coordinate values are used when you need to measure distances above the XY plane; negative values are used for the distances below the XY plane. (Illustrated with Fig. In CADD PRIMER)

Coordinate values are entered separated by commas (X,Y,Z). The coordinates can be measured from the origin point (absolute coordinates) or from the last reference location of the cursor (relative coordinates).

Spherical Coordinates

Spherical coordinates are based on the longitude and latitude system of measurement. Consider the origin point of the coordinate system at the center of the earth or a transparent globe. Then consider a horizontal plane (XY plane) passing through the center of the globe. To locate a point in 3D, first locate a point in the XY plane by specifying a radius and an angle (polar coordinates). To specify the height, enter an angle up or down from the XY plane (latitude). (Illustrated with Fig. In CADD PRIMER)

Note:

Spherical coordinates are not very efficient for drawing purposes. They are commonly used to view a model from different angles.

Cylindrical Coordinates

Cylindrical coordinates are commonly used to draw cylindrical shapes. They are based on a cylindrical system of measurement. Consider a cylinder placed vertically and the origin point at the center of the cylinder. Cylindrical coordinates are quite similar to spherical coordinates, the difference being that the Z-coordinate is specified by height and not angle. (Illustrated with Fig. In CADD PRIMER)

To locate a point with the cylindrical coordinates, first you need to locate it in the XY plane just like polar coordinates. Then indicate an exact height at that point.

Steps to Draw a 3D Model

(This exercise is described with the help of illustrations in CADD PRIMER).

User-defined Coordinate System

We discussed in Chapter 2, "CADD Basics", how a user-defined coordinate system can help to work with odd-shaped diagrams. Here is an example of using it in 3D. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Displaying Views

You can rotate a 3D model on the screen and display different views by specifying an exact viewpoint. The viewpoint represents the position of the camera from where a picture of the view is to be taken. You can define a viewpoint with the help of any of the coordinate methods discussed earlier.

There are two main protocols used to display views:

- View coordinate geometry
- Object coordinate geometry

View Coordinate Geometry

View coordinate geometry assumes that the camera (viewpoint) remains stationary and the 3D model is rotated to display a desired view. The model can be rotated around the X, Y, or Z axis. You need to specify around which axis the

rotation will take place and by how much. When you rotate the model around the Z-axis, the model rotates in the XY plane; when you rotate it around the Y-axis, the rotation takes place in the XZ plane. (Illustrated with Fig. In CADD PRIMER)

Object Coordinate Geometry

Object coordinate geometry assumes that the model remains stationary and the camera (viewpoint) is moved to a display a desired view. You can use any of the coordinate methods to specify an exact viewpoint. Spherical coordinates are particularly helpful to indicate a viewpoint. (Illustrated with Fig. In CADD PRIMER)

Comparison: View coordinate geometry can be compared to holding a small model in your hand and rotating it on its sides to get a desired view. Object coordinate geometry can be compared to viewing a building from the sky. The building remains stationary, while the camera is moved to get a desired view.

Note: Most CADD programs provide both view coordinate geometry and object coordinate geometry options to display views. Depending on how you want to view a model, you can use either method.

Displaying Isometric Views

To display an isometric, you need to specify the direction from which the view is to be taken. The most appropriate method to indicate direction is with the help of spherical coordinates. You need to specify two angles: an angle in the XY plane (longitude) and an angle from the XY plane (latitude). The longitude determines the orientation of the model in the XY plane and the latitude determines the height of the viewpoint. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Displaying Plans and Elevations

You can display standard 2D views such as plans and elevations by specifying the direction of the view. To display a plan view, you need to view the model from the top, that is, enter the angle from the XY plane (latitude) as 90°. To display an elevation, you need to view the model parallel to the XY plane, that is, enter the angle from the XY plane (latitude) as 0°. You can view an elevation from any angle by specifying an exact angle in the XY plane. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Displaying Perspective Views

CADD allows you to display perspective views from any angle of the model. You can display a true perspective by specifying an exact distance between the viewpoint and the model. (Specifying a distance is not necessary to display

parallel projection views such as plans, elevations and isometrics.) When you specify an exact distance, it causes the lines of the view to converge and display a true perspective (See Fig.). The closer the viewpoint, the greater the conversion takes place.

CADD programs use one of several different methods to display perspective views. A common method is to establish a line of sight between the viewpoint (camera) and the model (target). You can specify any distance along this line of sight to display an appropriate perspective view. (This topic is described in detail with the help of illustrations in CADD PRIMER).

3D Drawing-Aid Functions

The common 3D drawing-aid functions of CADD are described as follows:

- 3D ready-made shapes
- Linear extrusion
- Radial extrusion
- Shading and rendering

3D Ready-made Shapes

CADD allows you to draw a number of 3D ready-made shapes in a few simple steps. To draw a cube, you don't need to draw all the lines or 3D faces for each of its sides. You can instantly draw a cube by specifying its dimensions. Similarly, you can draw a number of commonly used geometrical shapes just by specifying their shape and size. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Important Tip:

Specialized engineering programs provide a number of additional 3D shapes to facilitate a 3D drawing. The 3D ready-made shapes can help build the skeleton of a model.

Extruding Objects in the Linear Direction

CADD allows you to extrude 3D shapes from 2D profiles. You can extrude a square to form a cube, a circle to form a cylinder, or a triangle to form a prism. When you use the linear extrusion function, you are prompted to select the objects to be extruded and specify the direction of extrusion (axis of extrusion). You can select any profile made of lines, arcs, polylines, or other objects and extrude it in any direction by specifying the axis of extrusion. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Extruding Objects in the Circular Direction

CADD allows you to extrude drawing objects along a circular path (called radial extrusion). For example, you can draw a section of a cylinder and extrude it to form the complete cylinder. To perform a radial extrusion, you are prompted to select the objects to be extruded, indicate an axis of revolution and an angle of extrusion. The axis of revolution acts as pivot point of the revolution and the angle of extrusion determines how much revolution will take place. (This topic is described in detail with the help of illustrations in CADD PRIMER).

Shading and Rendering

There are a number of shading and rendering programs available that can be used to make 3D drawings very realistic. These programs allow you to create colors, shades and shadows exactly as they would appear in a picture. These programs are quite large and complex and require powerful computer hardware.

With the help of rendering programs, you can specify a number of shading and rendering parameters and create a 3D scene. You can assign colors and textures to different surfaces of a model. You can specify light sources in a scene and specify what kind of light is used and how it is directed. You can create a special setting for the model, such as a landscape or interior.

This topic is described in detail in CADD PRIMER.

AutoCAD, MicroStation and Cadkey Terms

This topic lists important terms used in leading CADD programs. Refer to CADD PRIMER for details.

CADD PRIMER ordering information:

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